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13. SUPPLEMENTARY NOTES Two reprints in ACS conferences: Polym. Mat. Sci. 83(2000)122 and 83(2000)334.					
14. ABSTRACT A variable, mono-energetic slow positron beam (0-30 keV) coupled with Doppler broadening of annihilation radiation and positron lifetime measurements has been constructed at the University of Missouri-Kansas City. The beam is ideal for surface and materials characterization of defects of polymeric and coating materials in the range of sub-nanometer on the surface to a few μm in the bulk. This instrument becomes one of five slow positron beams currently available in the US for research on sub-nanometer defects and for training students and scientists in defense-related research. The performance of the beam, the counting rate and the resolution, is one of the best in the world.					
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A. Summary of the Progress and Important Accomplishments:

We have installed a slow positron beam with a capability of varying energy from 0 to 30 keV at the University of Missouri-Kansas City. The beam is designed for characterization of sub-nanometer defects, such as free volumes and holes at the atomic and molecular levels by monitoring the nature of positron-electron annihilation signals. This spectrometer is able to detect the early stage of coating degradation within hours of accelerated UV irradiation. It is one of five slow positron beams available for surface and materials characterization in the US.

Based on this research, a portable, field-based positron spectrometer for accelerated testing of coating degradation, such as a NDE instrument may become feasible in the future.

(1) The performance of the slow positron beam is one of the best among the existing slow positron beams in the world with the following specifications:

- a. Flux: 1×10^5 slow positrons per second at the sample by using 50 mCi of Na-22 positron source.
- b. The beam spot is on the order of 5 mm diameter.
- c. UHV chamber condition down to 1×10^{-10} torr.
- d. Measuring Doppler broadening of annihilation radiation for defect parameter.
- e. Positron lifetime measurements.
- f. The beam operation is automatically controlled by a Pentium III PC.

Fig. 1 shows the schematic diagram of the constructed beam.

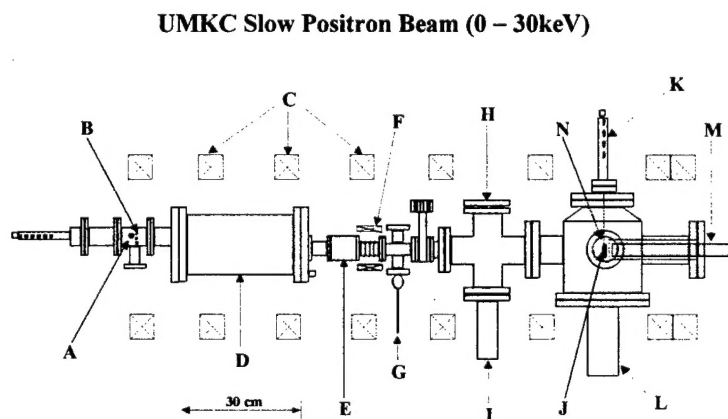


Figure 1. A schematic diagram of the slow positron beam at the University of Missouri-Kansas City. A: 50 mCi ^{22}Na positron source, B: W-mesh moderator, C: magnetic field (75G) coils, D: ExB filter, E: positron accelerator, F: correcting magnets, G: gas inlet, H: positron bunching system for PAL, I: turbo molecular pump, J: samples, K: sample manipulator, L: cryo pump, M: Ge solid state detector, N: lifetime detector.

(2) The built beam has been used to perform research projects in conjunction with grants of AFOSR (F49620-98-1-0162) and NSF (CMS98-12717). Main scientific results obtained from this beam are:

- a. The weathering resulting from controlled UV, xenon light, and humidity all reduce the defect (sub-nanometer) size and concentrations. The reduction of free-volume and holes induces the degradation and shortens the durability of coatings.
- b. The defect microstructure of polymers and coatings near the surface is very different from the bulk. Inhomogeneous chemical and physical profiles were determined. This gives us an important guide to search for the improvement of coating durability.
- c. Degradation of coatings is largely increased by a factor of about ten as the UV wavelength is shortened from 340 to 313 nm.
- d. UV degradation is through the photo-oxidation mechanism, which is propagated by the reaction between oxygen and polymer chains, the formation of free radicals, and the increase of crosslinking density.

B. These results have been published in the following refereed papers that acknowledge the AFOSR support:

1. "Free Volumes and Holes Near the Polymer Surface Studied by Positron Annihilation," *Appl. Surf. Sci.* 149(1999)116-124.
H. Cao, J.-P. Yuan, C.S. Sundar, Y.C. Jean, R. Suzuki, T. Ohdaira, and B. Nielsen.
2. "Application of Slow Positrons to Coating Degradation," *Rad.Phys.Chem.* 58(2000)645-648.
H. Cao, R. Zhang, H.M. Chen, P. Mallon, C.-M. Huang, Y. He, T.C. Sandreczki, Y.C. Jean, B. Nielsen, T. Friessnegg, R. Suzuki, T. Ohdaira.
3. "Positron Annihilation Studies of Chromophore-Doped Polymers," *Rad.Phys.Chem.* 58(2000)571-574.
C.-M. Huang, J.-P. Yuan, H. Cao, R. Zhang, Y.C. Jean, R. Suzuki, T. Ohdaira, B. Nielsen.
4. "Development of Positron Annihilation Spectroscopy for Accelerated Weathering of Protective Polymer Coating," *Rad.Phys.Chem.* 58(2000)639-644.
R. Zhang, H. Cao, H.M. Chen, P. Mallon, Y. He, T.C. Sandreczki, R.J. Richardson, Y.C. Jean, B. Nielsen, R. Suzuki, T. Ohdaira.

Two additional papers (un-refereed) have been published:

5. "Photo-degradation of Polymeric Coatings Studies by Positron Annihilation Spectroscopy," *ACS Polym. Mate. Sci. & Eng.* 83(2000)334-335.
Y.C. Jean, R. Zhang, H. Chen, P. Mallon, J. Zhang, Y. Li, C-M. Huang, T.C. Sandreczki, J. Richardson, R. Suzuki, T. Ohdaira, and B. Nielsen.

6. "Positron Annihilation Spectroscopy as a Novel Accelerated Method for UV Degradation of Polymers," *ACS Polym. Mater. Sci. & Eng.* 83(2000)122-123.
Y.C. Jean, Y. Li, P. Mallon, R. Zhang, H. Chen, P. Mallon, J. Zhang, C-M. Huang,
T.C. Sandreczki, Y.Y. Huang.